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Multi-satellite mission KAGUYA (SELENE)

S. Sasaki (1), N. Namiki (2), H. Hanada (1), H. Araki (1), T. Imamura (3), T. Iwata (3) and RSAT/VRAD/RS Group
(1) National Astronomical Observatory of Japan, Oshu, Japan, (2) PERC, Chiba Institute of Technology, Japan,
(3) ISAS/JAXA, Sagamihara, Japan
(sho@miz.nao.ac.jp / Fax:+81-197-22-7120)

Abstract

KAGUYA (SELENE) is Japanese three-satellite mission for global remote sensing of the Moon. It was launched on September 14th, 2007 by JAXA and ended its operation on June 10th, 2009. KAGUYA has two small subsatellites, Rstar (OKINA) and Vstar (OUNA) for gravity measurement. The three satellites are tracked by new methods: 4-way Doppler tracking between the ground station and the main satellite by way of Rstar for the farside gravity and multi-frequency differential VLBI tracking between Rstar and Vstar. Using Rstar and Vstar, radio science (RS) experiment in KAGUYA (SELENE) mission was conducted to examine the lunar ionosphere using the method of radio occultation.

1. Introduction

The Japanese lunar explorer KAGUYA (SELENE) was launched successfully on September 14th, 2007 by JAXA and ended its operation on June 10th, 2009. KAGUYA takes polar orbits and observed the global Moon by June 10, 2009. KAGUYA observed the Moon by 14 instruments. Among them, there are two subsatellites Rstar (OKINA) and Vstar (OUNA). KAGUYA obtained first global topography and gravity of the Moon.

2. Gravity measurements

Synchronous rotation of the Moon with its orbit inhibits a direct link between a ground tracking station on the Earth and a lunar-orbiting spacecraft over the farside. Previously lunar farside gravity was obtained indirectly from direct tracking data mostly on the nearside. KAGUYA has two small spin-stabilized subsatellites, Rstar (OKINA) and Vstar (OUNA) for gravity measurement. Their weight is 50kg each. The main satellite of KAGUYA takes polar orbits with 100km average altitude. Rstar takes polar orbits with perilune about 100km and apolune about 2400km, respectively. Vstar also takes polar orbits with perilune 100km and apolune 800km. We tracked the three satellites by new methods: 4-way Doppler tracking between the ground station and the main satellite by way of Rstar (Fig. 1) for the farside gravity and multi-frequency differential VLBI tracking between Rstar and Vstar (Fig. 2). It should be noted that precise determination of the orbit of Rstar by VLBI is important for the gravity measurement through the 4-way tracking of the main satellite.

The global lunar gravity field with unprecedented accuracy was obtained. KAGUYA obtained accurate lunar farside gravity for the first time [1]. The large error on the far-side in previous gravity models is drastically reduced. Many circular features corresponding to impact structures are clearly identified. Topographic depression and rim of far-side gravity basins show good correlation between topography and free-air gravity anomaly suggesting elastic support of lunar lithosphere. Using historical tracking data and 14.2 months of SELENE tracking data (from October 20, 2007 to January 30, 2009), spherical harmonic solution of the lunar gravity field to degree and order 100, called SGM100h, is obtained [2].

Assuming crustal density 2800 kg/m^3, mantle density 3360 kg/m^3, and mare basalt density 3200 kg/m^3 and assuming a uniform crust, Bouguer gravity anomaly, Moho depth and crustal thickness are estimated [3] from gravity and topography, which was obtained by laser altimeter (LALT).

3. Lunar ionosphere measurements

The radio science (RS) experiments in KAGUYA (SELENE) mission was conducted to examine the lunar ionosphere using the method of radio occultation. In the SELENE RS, using two radio frequencies of 2218 MHz and 8456.125 MHz transmitted from Vstar (OUNA), lunar ionosphere was observed. The two radio frequencies were used to extract the contribution from the electrons density along the ray path, especially from the terrestrial ionosphere. Additionally we use two subsatellites

Rstar (OKINA) and Vstar (OUNA) for the measurement. When Vstar is occulted by the lunar surface, radio signal from Rstar is used to measure the effect of terrestiral ionosphere. Difference between the signals from two satellites provides the lunar ionosphere component without being disturbed by the terrestrial ionosphere.

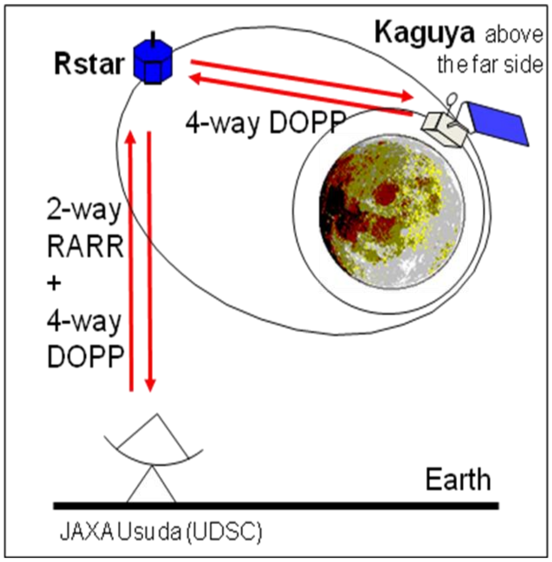

Figure 1: Principle 4-way Doppler observation of KAGUYA using Rstar.

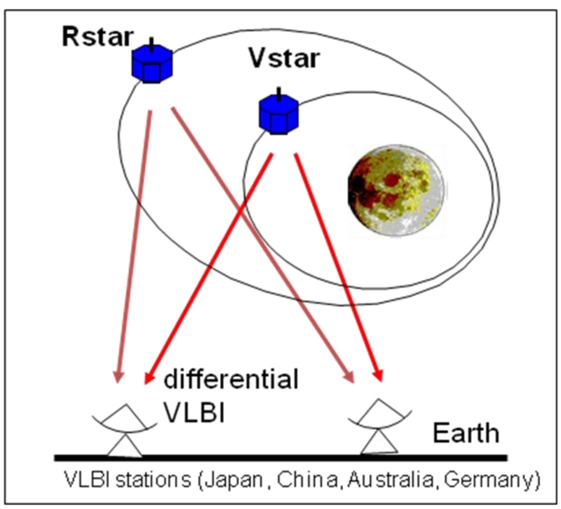

Figure 2: Principle of multi-frequency differential VLBI tracking between Rstar and Vstar.

References

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